State of California
The Resources Agency
Department of Water Resources

SP-T11 EFFECTS OF FUEL LOAD MANAGEMENT AND FIRE PREVENTION ON WILDLIFE AND PLANT COMMUNITIES DRAFT FINAL REPORT

Oroville Facilities Relicensing FERC Project No. 2100

OCTOBER 2003

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FERC Project No. 2100

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REPORT SUMMARY

Fuels management is not regulated under the Federal Energy Regulatory Commission (FERC). However, several stakeholders have expressed concern related to this land management issue within the FERC relicensing process and one stakeholder sponsored Resource Action has been proposed. The Department voluntarily agreed to gather information on this topic to determine whether to supplement its current compliance with all legal requirements.

The objective of this Study Plan is to assess the potential wildlife and plant community benefits and impacts associated with potential fuels management actions. The stakeholder submitted Resource Action was used in this evaluation as an example of the types of fuels management actions that may be undertaken and their possible impacts (positive and negative).

The study area for this evaluation is the 492 acres of State lands bordering the Kelly Ridge subdivision. Three potential scenarios were modeled using the California Wildlife Habitat Relationship Program.

- High severity wildfire over the entire study area (Scenario #1)
- Implementation of a 100-foot wide shaded fuelbreak along the project boundary within the study area (Scenario #2)
- Area-wide fuels reduction program within the study area (Scenario #3)

Of the three scenarios modeled, the shaded fuelbreak option provided the highest wildlife species richness benefits while minimizing adverse affects to wildlife and plant communities.

Area-wide fuels reduction has the potential to adversely impact total wildlife species richness and to decrease habitat suitability for 47 species.

A high severity wildfire would temporarily result in loss of habitat for 134 vertebrate wildlife species. This represents a significant short-term decrease in wildlife species richness. Further, a high intensity wildfire could cause significant direct wildlife mortality.

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1.0 INTRODUCTION

Several Relicensing stakeholders have expressed their concern that historical land management and fire prevention activities within the FERC project boundary have resulted in increased fuel loading which has led to an increased risk of wildfire. This issue was investigated by the Land Use, Land Management and Aesthetics Work Group (LUWG) under SP-L5. Preliminary evaluation of fuel hazard and potential fuels reduction options are outlined in Interim Report L5-Fuel Load Management Evaluation. Based on the information provided within this Interim Report, the California Department of Parks and Recreation (CDPR) has proposed a Relicensing Resource Action to address fuels management concerns along the project/urban interface in the vicinity of Kelly Ridge subdivision. Further, this potential Resource Action identifies two potential fuel load management options for this area.

The purpose of this report is to provide information to the LUWG and other stakeholders on the effects of potential fuel load management and fire prevention activities on wildlife and plant communities. This assessment will focus on those areas and fuels management options contained in the potential Resource Action. Further, this report will:

- Identify existing wildlife habitats based on habitat mapping presented in SP-T4. Use of the California Wildlife Habitat Relationships System (CWHR) for analyses requires that plant community mapping follow specific protocols including identification of age and cover classes for each habitat type.
- Predict current wildlife occurrence based on the CWHR modeling of existing habitats.
- Predict the habitat changes associated with a high severity wildfire.
- Predict the changes in wildlife occurrence associated with a high severity wildfire (CWHR analyses).
- Predict the habitat changes associated with the two fuels management options identified in the stakeholder proposed Resource Action.
- Predict wildlife species responses to habitat changes associated with implementation of fuels management options (CWHR analyses).

Wildlife responses to various habitat alterations are summarized in the text of this report while copies of each WHR modeling run are included as appendices.

1.1 BACKGROUND INFORMATION

1.1.1 Presettlement: Fire History

The evidence strongly suggests that fire is a natural evolutionary force that has influenced Sierran ecosystems for millennia, influencing biodiversity, plant reproduction, vegetation development, insect outbreak and disease cycles, wildlife habitat relationships, soil functions and nutrient cycling, gene flow, selection, and, ultimately, sustainability [Sierra Nevada Ecosystem Program (SNEP) 1996].

The various forest habitats and communities in the Sierra Nevada today were created by the influence of fire over thousands of years (Barbour et al. 1987). California has a Mediterranean climate with cool, wet winters and warm, dry summers, which provides suitable weather and dry fuels for burning. Lightning during thunderstorms provides a natural ignition source (SNEP 1996). Native Americans who inhabited the region were also known to frequently ignite forest fires for numerous cultural purposes (SNEP 1996). The Native Americans started low-burning fires to control understory growth from competing with desirable species such as oaks for acorn production (which was a main staple of their diet) for plants favorable for basket weaving, to clear brush around their homes, and to enhance habitat for game species (McKelvey et al. 1996; Skinner and Chang 1996). In the absence of suppression efforts, fires would spread until weather conditions or fuels were no longer suitable (SNEP 1996).

Much of the vegetation in the Sierra Nevada exhibits traits that allow survival and reproduction in this environment of regular fire. Prior to the mid-1800s many plant communities experienced fire at least once, and often a number of times, during the life spans of the dominant species (McKelvey et al. 1996). Chaparral and mixed conifer communities are especially adapted to regular and frequent fires and depend on fire for their reproduction and as a means of competing with other biota (SNEP 1996). Fire-scar records in tree rings have shown variable fire-return intervals in presettlement times, with median values consistently less than 20 years for the foothill, ponderosa pine, and mixed conifer zones of the Sierra Nevada (SNEP 1996). Intervals between fires vary depending on climate, elevation, topography, vegetation, soil chemistry, and human cultural practices (Skinner and Chang 1996).

The variable nature of presettlement fire helped create diverse landscapes and variable forest conditions (SNEP 1996). In many areas, frequent surface fires are thought to have minimized fuel accumulation, keeping understories relatively free of small trees and other vegetation that could form fuel ladders, which allow fire to move into the main canopy. The effects of frequent surface fires would largely explain reports and photographs of early Euro-American settlers who describe Sierran forests as typically "open and park-like" (SNEP 1996). However, there are also many reports from the same period that describe the forests as dark, dense, and impenetrable (SNEP 1996). From the differing reports, it is likely that Sierran forests were a mix of open forests and impenetrable stands of brush and young trees (SNEP 1996).

The way that fire affects the landscape is largely a result of its frequency (return-interval), spatial extent (size), and its magnitude. The magnitude of a fire refers to both its intensity and severity. Intensity is a technical term used to describe the amount of energy released from a fire and may or may not be directly related to fire effects. Severity is related to the change in the ecosystem caused by the fire. Fires that burn only surface fuels (i.e., surface fires), and in which most of the woody vegetation survives, are usually considered low-severity fires. Fires that kill most small trees, with only some of the subcanopy trees killed or damaged and occasionally overstory trees killed, are considered moderate-severity fires. Fires that kill large trees over more than a few acres by burning their crowns (i.e., crown fires) are usually considered high-severity fires (Skinner and Chang 1996).

Most presettlement fires were low to moderate severity, with only a few patches of high severity. High-severity fires likely occurred occasionally but were probably much less common than today. These conclusions are based on research of fuel dynamics, forest age structure analysis, written accounts of early fires, and observations of modern fires (SNEP 1996). More frequent fire-return intervals reduced the horizontal and vertical biomass in the forest, which regulated the severity of the fire at a low or moderate level and helped prevent crown fires (McKelvey et al. 1996; Skinner and Chang 1996). As a result, the landscape consisted of a mosaic of forest patches in a variety of stand ages, which is more likely to function as a diverse ecosystem than an even-aged stand generated by a severe and widespread fire (Skinner and Chang 1996).

Another difference between presettlement and current fire patterns is the location of the fires. The presettlement return interval for fires in the foothills (i.e., blue oak forest) through the upper mixed conifer zone did not differ much (See Table 1.1-1). However, recent fire patterns show a decrease in fire frequency with an increase in elevation. The distribution of fires in the 20th century is closely associated with drought conditions and probably is due to effective suppression of low- to moderate-intensity fires. Before settlement, 10 times as much area in the foothills burned when compared with the 20th century, and 60 times as much burned in the red fir zone (McKelvey et al. 1996).

Table 1.1-1. Historical and contemporary fire-return intervals.

Forest Type	Fire-Return Interval (Years)	
	20th Century	**Pre-1900**
Red fir	1,644	26
Mixed conifer-fir	644	12
Mixed conifer-pine	185	15
Ponderosa pine	192	11
Blue oak	78	8

Source: SNEP 1996

Periodic fires performed a number of ecological functions. Fire damaged or killed some plants, creating conditions for regeneration or vegetation succession (SNEP 1996). Fire influenced many processes in the soil and forest floor by consuming organic matter and inducing thermal and chemical changes. Nutrient cycling is also affected by fire. Periodic fires removed biomass from small shrubs and trees, which contribute to surface and ladder fuels and promoted large tree growth. Periodic fires also generate mosaics of vegetation in different successional stages across the landscape (SNEP 1996).

1.1.2 Euro-American Settlement: Logging and Fire Suppression

Euro-American settlement following the discovery of gold in California in the mid-1800s initiated profound changes in the role of fire in Sierra Nevada ecosystems (SNEP 1996). Many factors have influenced changes in fire patterns in the Sierras over the last century (e.g., population decline among native peoples, grazing, mining, logging, recreation, settlement, fire management) (McKelvey et al. 1996; Skinner and Chang 1996). However, logging and fire suppression are probably the two most significant activities that have influenced forest fuels due to the intensity and widespread distribution of these activities.

Logging was initially undertaken to supply mines and later to support the growing population of the new state. Timber volumes harvested in the Sierras continued to increase into the 20th century, reaching a peak in the 1970s and 1980s (SNEP 1996). Typically, loggers harvested large trees and fire-resistant species, and these were replaced by more fire-susceptible smaller trees. This pattern of biomass removal contrasted markedly with that of presettlement surface fires, which tended to kill small trees and leave many large trees to survive (SNEP 1996). Logging also tends to result in large quantities of debris left on the ground, which contributes to fuel loading and to severe fires (McKelvey et al. 1996). The forest management practices used in the 20th century have significantly contributed to a younger, denser, more homogenous forest structure (McKelvey et al. 1996).

The settlement of the Sierras also resulted in an emphasis to extinguish any and all fires to protect property and homes. After a series of disastrous fires in 1910 and a period of trial and debate about the merits of "light burning" as a management tool in forests and rangelands, intentional broadcast burning was repudiated and aggressive fire control became firmly established as State and federal policy (SNEP 1996). Combined with the loss of ignitions by Native Americans, fire suppression activities significantly reduced the area burned by wildfires during the last century (SNEP 1996). Although fire suppression efforts have varied throughout the landscape, depending on location, severity, accessibility, cost, and vegetation type, the policy emphasized keeping wildland fires as small and inexpensive as possible (Husari and McKelvey 1996).

The virtual exclusion of widespread low- to moderate-severity fires has affected the structure and composition of most Sierra Nevada vegetation, especially in low- to middle-elevation forests. Conifer stands generally have become denser and consist of mainly small and medium size classes of shade-tolerate and fire-sensitive tree species. Vertical fuels have become more continuous, contributing to higher risk of canopy fires. In combination with the removal of large trees for timber, conditions have promoted the establishment of dense, young forests. As a result, stands in many areas have experienced increased mortality recently from the cumulative effects of competition (primarily for water and light), drought, insects, disease, and in some cases air pollution (SNEP 1996).

Today's forest conditions more readily support severe fires due to the structure of the forest vegetation and the accumulation of fuel (McKelvey et al. 1996). The increased density of young trees together with increased fuels from fire suppression and tree mortality has created conditions favorable to more intense and severe fires. The understory vegetation is left to flourish, providing a connection between ground fuels and the canopy trees, in addition to adding fuel to the forest floor. The denser forests have intertwined canopies, allowing for fire to spread easily from one tree to the next in the canopy. Moreover, severe fires are more likely to be large in size because they are more difficult to suppress (SNEP 1996). After a widespread and severe fire, large areas of even-aged stands regenerate, decreasing the variability of the landscape (McKelvey et al. 1996).

Human settlement in the Sierra Nevada is continuing, and the populations of many communities have been rapidly increasing in the last few decades (SNEP 1996). The propensity of people to build homes in forested areas without mitigating fire hazards and risks has increasingly placed homes and other valuable property at risk to loss from severe wildfires (SNEP 1996). Although fire fighting technologies have improved and many resources are dedicated to protecting people, structures, and other resources, many hundreds of homes have been destroyed by wildfires in the Sierra over the past few decades (SNEP 1996).

In summary, three major fire-related "problems" have been identified in the Sierra Nevada:

(1) Too much high-severity fire and high probability for future high-severity fires if fuel load condition trends continue;
(2) Too little low- to moderate-severity fire, with a variety of ecological changes attributed at least in part to this deficiency; and
(3) A large number of homes and other structures at risk due to both existing and continued rural development in areas with extreme fire hazards that are not reduced to acceptable levels (SNEP 1996).

Source: Quincy Library Group, Hungry Creek Fuel Project

1.1.3 Statutory/Regulatory Requirements

1.1.4 Study Area

The study area for this assessment includes about 490 acres within the project boundary adjacent to the Kelly Ridge subdivision area (Figure 1.1.4-1).

Figure 1.1.4-1 Kelly Ridge Study Area

1.1.4.1 Description

Kelly Ridge forms a northeasterly tending peninsula within Lake Oroville. Slopes are generally moderate, averaging 10 to 20 percent. Aspect is both northwest and east. Major project facilities within the study area include trails, campgrounds, roads, a visitor center, boat ramps, marina storage facilities, and parking areas. These developed areas occupy approximately 33 acres within the study area.

Wildlife habitat mapping (Figure 1.1.4-2) indicates that blue oak/foothill pine is the dominant habitat type within the project boundary and occurs on about 89 percent of the total study area (Table 1.1.4-1). Other habitat types include annual grassland, barren, freshwater emergent wetland, mixed chaparral, montane hardwood, urban/disturbed and valley foothill riparian.

Table 1.1.4-1 Major CWHR habitat types present within the study area.

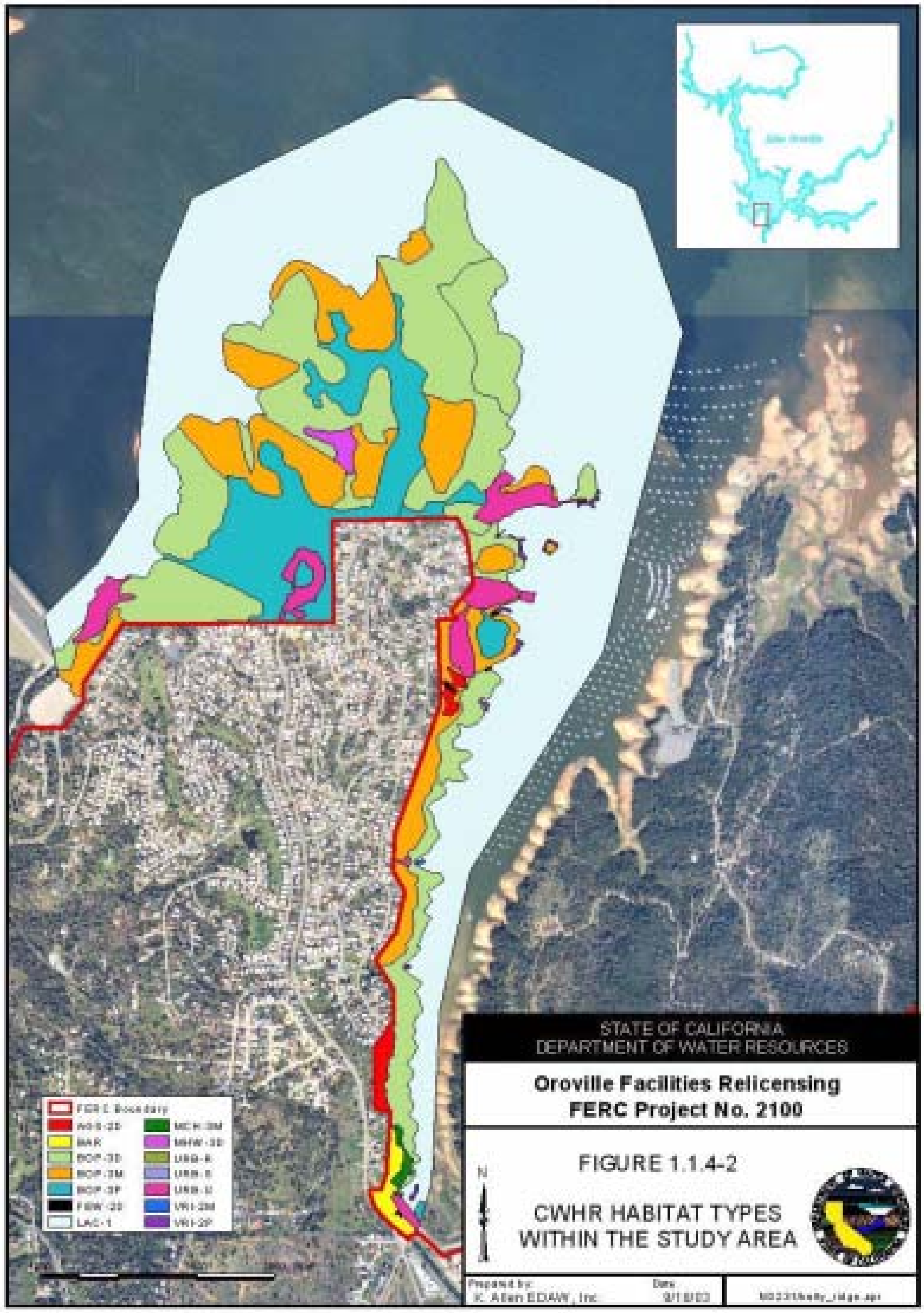
Habitat Type	CWHR Code	Acreage
Annual grassland	AGS	6.19
barren	BAR	6.23
Blue oak/foothill pine	BOP	438.55
Freshwater emergent wetland	FEW	0.43
Mixed chaparral	MCH	1.90
Montane hardwood	MHW	3.98
Urban/disturbed	URB	32.58
Valley foothill riparian	VRI	2.12

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

Figure 1.1.4-2 CWHR Habitat Types Within Study Area



The hydroelectric facilities have a combined licensed generating capacity of about 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam, creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (CDFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

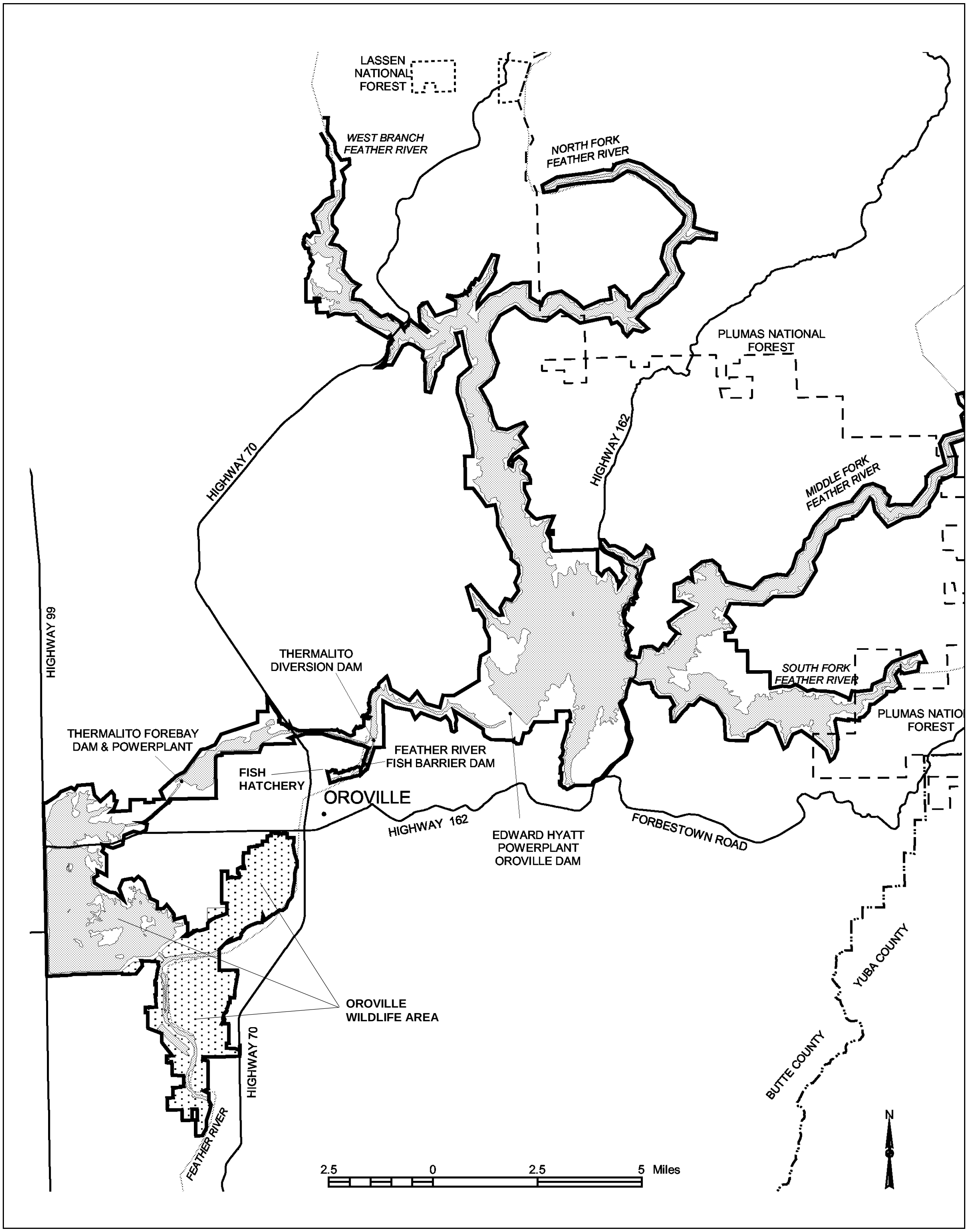


Figure 1.2-1. Oroville Facilities FERC Project Boundary

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning are conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, “Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife,” sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the

Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

NOAA Fisheries has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson’s Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California Independent System Operator (ISO) anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

Several stakeholders have expressed concern related to this land management issue within the FERC relicensing process and one stakeholder sponsored Resource Action has been proposed.

3.0 STUDY OBJECTIVE(S)

The objective of this Study Plan is to assess the potential wildlife and plant community benefits and impacts associated with potential fuels management actions.

3.1. Settlement Agreement

Implementation of any fuels management option would be based on a Settlement Agreement.

4.0 METHODOLOGY

The methodologies presented in this report have been modified slightly from those presented in the study plan to tailor the analyses to the Land Use, Land Management and Aesthetics Work Groups current needs as related to the proposed Resource Action. Analyses of the ecological effects of existing fire prevention practices (study plan tasks 3 and 4) were replaced with an analysis of the ecological effects of wildfire within the study area.

The CWHR system is state-of-the-art informational database that describes the management status, distribution, life history and habitat requirements of 675 of California's vertebrate wildlife species (Airola 1988). CWHR also provides predictive models that serve as a tool to analyze wildlife species responses to habitat alterations. CWHR represents the most extensive compilation of wildlife habitat information in California. The information in CWHR is a compilation of published and unpublished data as well as professional judgement by species experts.

CWHR is operated and maintained by the CDFG in cooperation with the California Interagency Wildlife Task Group (CIWTG). CIWTG is comprised of representatives from the major State and federal natural resource management agencies and has worked cooperatively with CDFG for over 17 years to refine and further develop CWHR.

All CWHR analyses conducted as part of this evaluation are weighted habitat value comparisons of two situations (baseline and treatment) using a geometric mean. The "weighting" used was the acres of each seral stage of each habitat type treated under each comparison. CWHR habitat value comparisons allow species-by-species evaluation of the degree of change in habitat value between current conditions and those that might exist following wildfire or fuels management activities (Airola 1988). Use of a geometric mean rather than an arithmetic mean allows more inclusive species evaluation.

4.1 STUDY DESIGN

4.1.1 Data Collection

The primary sources of information includes the annual proceedings of the Tall Timbers Fire Ecology Conference, discussion with Pacific Southwest Range and Experiment Station fire ecologists, fire ecology literature reviews, and other scientific literature. An additional data source includes observation of the vegetative community response to historic fuels management activities and wildfire within the local area. Coordinate with the Land Use, Land Management and Aesthetics Work Group to identify potential fuel load management strategies to evaluate.

4.1.2 Habitat Mapping
Evaluate mapping of plant communities/wildlife habitats under SP-T4 (DWR 2003).

4.1.3 Ecological Effects of Wildfire
Use the information collected in 4.1.1, to develop predictions of and model the potential ecological effects of moderate to high intensity wildfire on each of the major plant communities present within the study area (Scenario #1). These predictions may include changes in plant succession, density, distribution, size classes, plant species composition, stand structure, understory development, ground cover as well as changes in other physical and biological characteristics.

4.1.4 CWHR Analyses of Wildfire
Use the California Wildlife/Habitat Relationships Database (CWHR) to input the plant community changes identified and modeled in 4.1.3 (Scenario #1). CWHR will predict which wildlife species may benefit from the predicted habitat changes as well as those species that could be adversely impacted.

4.1.5 Ecological Effects of Fuels Management Options
Use the information collected in 4.1.1 and 4.1.2 to develop predictions of and model the potential impact of fuels reduction activities on each major plant community within the study area. These predictions may include changes in plant succession, stand density, species and community distribution, size classes, plant species composition, stand structure, understory development, shrub density and ground cover as well as changes in other physical and biological characteristics.

The Resource Action identifies two potential fuels management options or scenarios. Scenario 2 involves development and maintenance of a 100-foot wide shaded fuelbreak along the project boundary within the Kelly Ridge study area. Scenario 3 involves an area wide fuels reduction program within the entire study area on a rotating basis.

4.1.6 CWHR Analyses of Fuels Management Options
Use the CWHR Database to input the plant community changes identified and modeled in 4.1.5. CWHR model output will predict which wildlife species benefit from the predicted habitat changes as well as those species that could be adversely impacted.

5.0 STUDY RESULTS

5.1.1 Data Collection

Data collection efforts focused primarily on literature review of wildfire as a direct cause of wildlife mortality and responses of local plant communities to moderate to high severity wildfire. Additional field observations of different fuels management options and wildfires in local plant communities was also useful for modeling habitat changes

5.1.2 Habitat Mapping

CWHR code definitions are provided in Appendix A. Habitat mapping represents habitat conditions at the time of aerial photography (1996). For the purpose of these analyses the habitat mapping will be considered as baseline conditions.

5.1.3 Ecological Effects of Wildfire-Scenario #1

Fire is a natural component of the Sierra Nevada foothill communities. Low elevation blue oak foothill pine forests like those dominating the Kelly Ridge study area experienced presettlement fires that were frequent, low to moderate in severity, and collectively covered large areas (SNEP 1996). Tree ring analyses indicate that the presettlement fire return interval was 8 years. Fire prevention/control activities during the 20th century have increased the fire return interval to 78 years in the blue oak/foothill pine community.

The far greater fire return intervals of the 20th century allow for greater horizontal and vertical fuels accumulations to occur between fires resulting in more intense and severe fires. Under high severity fires small subcanopy trees are killed with many or most overstory trees killed (Skinner and Chang 1996). These high severity fires remove the shrub layer, consume litter, down logs, and snags, and return the vegetative communities to an early successional stage. The existing habitats within the study area were modeled (using CWHR) to reflect a high severity fire. Modeled changes included returning most habitat types to an early and less dense seral stage, removal of buildings, campgrounds, brush piles, fences, herbaceous layer, shrub layer, tree layer, logs, slash, snags, and rotten stumps.

5.1.4 CWHR Analyses of Wildfire-Scenario #1

Baseline Condition-Under existing habitat conditions, CWHR analyses indicate that the habitats present within the study area could provide habitat for 354 species of wildlife including:

- 14 species of amphibians
- 246 species of birds
- 72 species of mammals
- 22 species of reptiles

CWHR analyses of the effects of a high severity wildfire on wildlife in the study area are summarized in Table 5.1.4-1. The complete CWHR model output is displayed in Appendix B. The habitat alterations produced by a wildfire create conditions that are generally favorable to reptiles and amphibians with 77 percent and 71 percent, respectively of the species responding positively to the newly created open conditions. Representative reptile and amphibian species which exhibited habitat preference for the post-wildfire habitat conditions include: western fence lizard, western terrestrial garter snake, western skink, ring-necked snake, western aquatic garter snake, common garter snake, western rattlesnake, gopher snake, and California slender salamander.

Table 5.1.4-1. Percentage of affected species in each taxonomic class by type of effect –post high severity wildfire (Scenario #1)

Response	Amphibians	Birds	Mammals	Reptiles
Habitat Created	0.00	0.40	0.00	0.00
Habitat Value Increased	71.43	17.74	34.72	77.27
Habitat Value Unchanged	7.14	33.87	8.33	0.00
Habitat Value Decreased	21.43	8.06	11.11	13.64
Habitat Lost	0.00	39.92	45.83	9.09
Totals	100.00	100.00	100.00	100.00

About 21 percent of the amphibian species showed decreasing habitat values while 7 percent remained unchanged. Examples of amphibian species which would experience decreased habitat suitability under the post-wildfire conditions include California newt, rough-skinned newt, and mountain-yellow-legged frog.

About 14 percent of the reptile species exhibited decreased habitat suitability post-wildfire. Examples of these species include sharp-tailed snake, western pond turtle, and northern alligator lizard. The wildfire created conditions where all habitat suitability was lost for 2 reptiles (sagebrush lizard and western whiptail). Both species are strongly dependant upon the presence of a shrub layer.

Post-wildfire conditions were generally unfavorable for bird species diversity with about 48 percent of the species (119 species) exhibiting either decreased habitat suitability (8.06 percent) or complete habitat unsuitability (39.92 percent). Bird species most strongly impacted by the post-wildfire conditions were those species strongly dependent on denser cover including Bewick’s wren, bushtit, western scrub jay, western screech owl, orange crowned warbler, warbling vireo, and house wren. CWHR predicted that approximately 18 percent of the bird species (45 species) would respond favorably to the post-wildfire habitat conditions including Say’s phoebe, cliff swallow, barn owl, lesser nighthawk, dark-eyed junco, common raven, burrowing owl, and killdeer.

Post-wildfire conditions were generally unfavorable to mammal species diversity with almost 57 percent of the species (41 species) exhibiting decreased habitat suitability

(11.1 percent) or complete habitat unsuitability (45.8 percent). Examples of mammalian species adversely impacted under the post-wildfire condition include western gray squirrel, gray fox, fringed myotis, black bear, Yuma myotis, and striped skunk. Twenty-five mammal species (34.7 percent) exhibited increased habitat suitability under the post-wildfire condition including black rat, Norway rat, house mouse, broad-footed mole, and long-eared myotis.

In general the immediate post-fire habitat conditions modeled under this scenario were strongly unfavorable to wildlife species richness with complete habitat unsuitability for 134 species (37.7 percent) and decreased habitat suitability for 34 species (9.5 percent). Approximately 27 percent of the species responded favorably to the immediate post-fire conditions.

The habitat modifications modeled under this scenario are undoubtedly more severe than would be expected as the high fuel loads required to result in the high severity wildfire modeled are not evenly distributed across the study area. This modeling effort should be considered as a worst case scenario. It is likely that pockets of unburned or lightly burned habitats would remain where larger logs, snags, and patches of tree or shrub understory would exist post-wildfire. Further, it is important to note that many of the plant species present within the study area are strongly adapted to fire and vigorous regrowth of shrubs, trees, and the herbaceous layers could be expected to occur.

In addition to the post-wildfire habitat alterations modeled above, high severity wildfire can be a direct cause of wildlife mortality through burns, heat stress, asphyxiation, physiological stress, trampling by other animals, and predation. CWHR modeling does not account for these potential losses. Even large highly mobile species like adult mule deer are occasionally killed in wildfires (Cowan 1956, Hines 1973). More sedentary species are most at risk from wildfire. Direct fire related mortality has been documented for woodrats (Howard and others 1959, Wright and Bailey 1982), voles (Ver Steeg and others 1983), and deer mice (Chew and others 1959). Many reptiles, amphibians, and small mammals may survive wildfires by taking refuge in underground burrows or rocky areas (Kahn 1960, Wirtz 1982). In general birds and most mammals are mobile enough to flee wildfires. However, a high intensity wildfire during the spring or early summer can result in loss of the less mobile young of the year or eggs (Nichols and Menke 1984).

5.1.5 Ecological Effects of Fuels Management Options-Scenario #2

Scenario #2 involves the creation of a 100-foot wide, 3-mile long, 33 acre shaded fuelbreak along the project boundary (urban interface). Within this 100-foot strip shrubs, small trees, and dead woody materials (slash, snags, and logs) would be removed (either mechanically or by hand crews). Mature overstory trees would remain but canopy closure would be reduced in stands where tree or shrub cover currently exceeds 40 percent. Regular repeated maintenance would be required to keep the shaded fuelbreak clear of ladder fuels and accumulations of down woody debris. The purpose of the shaded fuelbreak is to create a condition where reduced ground fuels and ladder fuels result in a lower severity, slower moving, more controllable ground fire while maintaining a somewhat natural setting. Current acreage of each habitat type and seral stage within the 100-foot wide shaded fuelbreak are displayed in Table 5.1.5-1. Baseline spatial scale of analyses is the same 492 acre study area employed in the two other modeling scenarios.

Table 5.1.5-1. Current acreage of habitat types subject to treatment in Scenario #2.

Habitat Type	Size Class	Density Class	Acreage
Blue oak/foothill pine	6 to 11 inch dbh	25 to 39% canopy closure	7.9
Blue oak/foothill pine	6 to 11 inch dbh	40 to 59% canopy closure	11.1
Blue oak/foothill pine	6 to 11 inch dbh	60 to100% canopy closure	7.9
Urban	-	-	1.2
Barren	-	-	4.1
Mixed chaparral	mature	40 to 59% ground cover	0.2
Annual grassland	Tall > 12 inches height	60 to 100% ground cover	0.9
dbh=diameter at breast height			

CWHR modeling under this scenario assumed no modification of urban, freshwater emergent wetland, valley foothill riparian, barren, or annual grassland habitats. Chaparral habitats within the fuelbreak would be thinned to less than 25 percent ground cover. Blue oak/foothill pine habitats within the fuelbreak would be subject to understory tree and shrub removal and canopy coverage decreases to less than 40 percent. All shrubs, snags and woody dead and down materials within the fuelbreak area would be removed.

5.1.6 CWHR Analyses of Fuels Management Options-Scenario #2

Under current conditions CWHR predicts that a total of 354 species may occur within the habitats present under this scenario including:

- 14 amphibian species
- 246 bird species
- 72 mammal species
- 22 reptile species.

Under Scenario #2 CWHR analyses indicate that 13 amphibian species would experience at least some incremental increase in habitat suitability while no amphibian species would be adversely impacted (5.1.6-1). Examples of amphibian species predicted to respond favorably to the habitat modifications associated with Scenario #2 include bullfrog, western toad and Pacific chorus frog.

Table 5.1.6-1. Percentage of Affected Species in Each Taxonomic Class by Type of Effect under Scenario #2

Response	Amphibians	Birds	Mammals	Reptiles
Habitat Created	0.00	3.66	0.00	0.00
Habitat Value Increased	92.86	43.09	80.56	95.45
Habitat Value Unchanged	7.14	47.56	18.06	4.55
Habitat Value Decreased	0.00	5.69	1.39	0.00
Habitat Lost	0.00	0.00	0.00	0.00
Totals	100.00	100.00	100.00	100.00

Under Scenario #2, CWHR predicts that the habitat modifications will provide at least some suitable habitat for nine bird species (fox sparrow, pileated woodpecker, flammulated owl, and Lewis woodpecker) not present under the baseline condition. No currently present bird species are predicted to be eliminated. One hundred and six bird species exhibit a favorable response to the habitat modifications associated with this scenario while 14 species could experience at least some incrementally reduced habitat suitability. Examples of avian species responding positively to this scenario include species favoring larger average tree sizes or more open canopy closure classes like great horned owl, house finch, phainopepla, and Bullock’s oriole. Examples of species which would experience at least incrementally reduced habitat suitability include species strongly associated with dense cover like Cooper’s hawk, winter wren, Swainson’s thrush and Stellar’s jay.

CWHR modeling of Scenario #2 indicates that 58 mammal species (81 percent) would respond favorably, while one species would be adversely affected. Those species responding favorably include species which reproduce or forage in more open habitats or favor larger tree sizes. The habitat modification modeled in Scenario #2 would not result in the addition or loss of any mammalian species.

The reptile species response to Scenario #2 is entirely favorable as CWHR predicts increased habitat value for 21 of the 22 species present.

In general, total wildlife species richness would be increased as habitat for nine additional species would be added without the loss of a single species. Over 57 percent of the species would experience at least some incremental increase in habitat suitability, while four percent would experience decreased habitat suitability. It is important to note that the percentage of the total study area treated under this scenario is relatively minor (5.5 percent) and that using the CWHR weighted habitat value comparison method most of the changes in habitat values are relatively minor. The complete CWHR model output for Scenario #2 is displayed in Appendix C.

5.1.7 Ecological Effects of Fuels Management Options-Scenario #3

Scenario #3 involves the area-wide fuels reduction within the 490 acre study area. Within this area, shrubs, small trees, and dead woody materials (slash, snags, and logs) would be removed (either mechanically or by hand crews). Mature overstory trees would remain but canopy closure would be reduced in stands where tree or shrub cover currently exceeds 40 percent. Regular repeated maintenance would be required to keep the treatment area clear of ladder fuels and accumulations of down woody debris. Under this scenario, reduced ground fuels and ladder fuels would result in a lower severity, slower moving, more controllable ground fire while maintaining a somewhat natural setting. Current acreage of each habitat type and seral stage within the study area are displayed in Table 5.1.7-1.

Table 5.1.7-1. Current acreage of habitat types subject to treatment under Scenario #3.

Habitat Type	Size Class	Density Class	Acreage
Blue oak/foothill pine	6 to 11 inch dbh	25 to 39% canopy closure	95.7
Blue oak/foothill pine	6 to 11 inch dbh	40 to 59% canopy closure	116.7
Blue oak/foothill pine	6 to 11 inch dbh	60 to100% canopy closure	226.2
Urban	-	-	32.6
Barren	-	-	6.2
Mixed chaparral	mature	40 to 59% ground cover	1.9
Annual grassland	Tall > 12 height	60 to 100% ground cover	6.2
Freshwater emergent wetland	Tall > 12 height	60 to 100% ground cover	0.4
Montane hardwood	6 to 11 inch dbh	40 to 59% canopy closure	3.9
Valley foothill riparian	1 to 6 inch dbh	40 to 59% canopy closure	0.1
Valley foothill riparian	1 to 6 inch dbh	25 to 39% canopy closure	2.0
dbh=diameter at breast height			

CWHR modeling under this scenario assumed no modification of urban, freshwater emergent wetland, valley foothill riparian, barren, or annual grassland habitats. Chaparral habitats would be opened to less than 25 percent ground cover. Blue oak/foothill pine and montane hardwood habitats would be subject to understory tree and shrub removal and canopy coverage decreases to less than 40 percent. All snags and woody dead and down material would be removed.

5.1.8 CWHR Analyses of Fuels Management Options-Scenario #3

Baseline conditions-Under current conditions CWHR predicts that a total of 354 species may occur within the habitats present under this scenario including:

- 14 amphibian species
- 246 bird species
- 72 mammal species

- 22 reptile species.

CWHR modeling of Scenario #3 indicates that about 29 percent of amphibian species (6 species) respond favorably while about 14 percent (5 species) are negatively affected (Table 5.1.8-1). Habitat alterations do not result in the loss or gain of any amphibian species. Examples of amphibian species which were positively affected include western spadefoot, western toad and rough skinned newt. Examples of species adversely affected include esatina, California newt, and California slender salamander.

Table 5.1.8-1. Percentage of Affected Species in Each Taxonomic Class by Type of Effect under Scenario #3

Response	Amphibians	Birds	Mammals	Reptiles
Habitat Created	0.00	0.81	0.00	0.00
Habitat Value Increased	28.57	31.71	36.11	68.18
Habitat Value Unchanged	57.14	59.35	31.94	22.73
Habitat Value Decreased	14.29	6.10	19.44	4.55
Habitat Lost	0.00	2.03	12.50	4.55
Totals	100.00	100.00	100.00	100.00

CWHR analyses indicate that about 33 percent of the bird species respond favorably to the habitat modifications associated with Scenario #3. These habitat modifications provide suitable habitat for two bird species which were not predicted to be present under baseline conditions (pileated woodpecker and black-throated sparrow). However, CWHR predicts that Scenario #3 will modify habitats of five bird species to unsuitable levels. An additional 15 bird species are predicted to find the modified habitat less suitable. Examples of these species include Cooper's hawk, California towhee, spotted towhee, and orange-crowned warbler. These species are generally associated with either dense cover or the presence of forest litter.

Predicted mammalian responses to Scenario #3 include habitat unsuitability and loss of nine mammal species currently predicted to be present including striped skunk, dusky-footed woodrat, brush rabbit, and brush mouse. About 36 percent of the mammal species (26 species) respond favorably to the habitat alterations in Scenario #3 including gray fox, Botta's pocket gopher, and broad-footed mole.

Reptile species generally respond favorably to the physical habitat changes associated with Scenario #3. Only two reptile species exhibit decreased habitat suitability or habitat loss under this scenario, while 15 species (68 percent) were predicted to respond favorably. Habitat for western whiptail, a species strongly associated with woody down material and the presence of a shrub layer, would be eliminated.

CWHR predictions indicate that Scenario #3 would result in decreased total wildlife species diversity with the loss of habitat for 15 species while gaining only two species.

Increased habitat suitability is predicted for 123 species. Decreased habitat suitability is predicted for 32 species, while 182 species would be unaffected by this fuels management strategy. The CWHR model predictions for each species are displayed in Appendix D.

6.0 ANALYSES

A high severity wildfire within the study area (Scenario #1) has the potential to kill some resident wildlife. Further, a high severity wildfire would temporarily result in loss of habitat for 134 vertebrate wildlife species, a significant short-term decrease in wildlife species richness (Table 6.1-1).

Table 6.1-1. Summary of total wildlife species response to modeled scenarios

Response	High Severity Wildfire Scenario #1	Shaded Fuelbreak Scenario #2	Area-Wide Fuels Reduction Scenario #3
Habitat Created	1	9	2
Habitat Value Increased	96	198	123
Habitat Value Unchanged	91	132	182
Habitat Value Decreased	34	15	32
Habitat Lost	134	0	15
Total:	356	354	354

Construction and maintenance of Scenario #2 (shaded fuelbreak) or #3 (area-wide fuels reduction) are unlikely to cause direct wildlife mortality (assuming construction and maintenance activities are scheduled outside the breeding season).

Analyses of Scenario #2 (shaded fuelbreak) indicate that this fuels management option offers some substantial opportunities for increased wildlife species richness while minimizing adverse affects. However, the relatively small area treated serves to minimize both the positive and negative benefits to relatively incremental affects.

Scenario #3 has the potential to adversely impact total wildlife species richness and to decrease or eliminate habitat suitability for 47 species. Substantial wildlife species richness increases and more significant increases in habitat suitability values could be gained by retaining some fairly large blocks of unmanipulated, dense habitat surrounded by treated areas. However, this treatment mosaic option would not accrue the same level of fuels reduction benefits that would be realized under implementation of Scenario #3.

7.0 REFERENCES

Airloa, D. A. 1988. Guide to the California wildlife habitat relationships system. Jones and Stokes Associates, Sacramento CA., 74pp.

Barbour, M.G, J.H Burke, and W.D. Pitts. 1987. Terrestrial Plant Ecology. The Benjamin/Cumming Company, Menlo Park, CA. Second Edition.

Chew, R. M., Butterworth, B. B., and R. Grechman. 1959. The effects of fire on the small mammal populations of chaparral. Journ. of Mammal. 40(2):253

Cowan, I. M. 1956. The black-tailed deer. In Taylor, W. P. ed. The deer of North America. Harrisburg, PA: The Telegraph Press 521-617.

DWR (Department of Water Resources). 2003. Vegetation mapping GIS database. Preliminary results. March 12, 2003.

Hines, W. W. 1973. Black-tailed deer populations and Douglas fir reforestation in the Tillamook Burn, Oregon. Game Research Report Number 3. Federal Aide to Wildlife Restoration, Project W-51-R, Final Report. Corvallis, OR: Oregon State Game Commission. 59 pp.

Howard, W. E., Fenner, R. L., and H.E. Childs. 1959. Wildlife survival in brush burns. Journ. of Range. Manage. 12: 230-234.

Husari, S.J. and K.S. McKelvey. 1996. Fire-Management Policies and Programs. Pages 1101-1117 In: Status of the Sierra Nevada, Sierra Nevada Ecosystem Project, Final Report to Congress, vol. II, Assessments and Scientific Basis for Management Options. University of California, Centers for Water and Wildland Resources, Davis.

Kahn, W. C. 1960. Observations on the effects of a burn on population of Sceloporus occidentalis. Ecology. 41:358-359.

Mayer, K.E. and W.E. Laudenslayer, Jr. 1988. A Guide to Wildlife Habitats of California. California Department of Forestry and Fire Protection, Sacramento, CA. October 1988.

McKelvey, K.S., C.N Skinner, C. Chang, D.C. Erman, S.J. Husari, D.J. Parsons, J. W. van Wagtendonk, and C.P. Weathersopoon. 1996. An Overview of Fire in the Sierra Nevada. Pages 1033-1041 In: Status of the Sierra Nevada, Sierra Nevada Ecosystem Project, Final Report to Congress, vol. II, Assessments and Scientific Basis for Management Options. University of California, Centers for Water and Wildland Resources, Davis.

Nichols, R.; Menke, J. 1984. Effects of chaparral shrubland fire on terrestrial wildlife. In: DeVries, Johannes J., ed. Shrublands in California: literature review and research needed for management. Contribution No. 191. Davis, CA: University of California, Water Resources Center: 74-97.

Skinner, C.N. and C. Chang. 1996. Fire Regimes, Past and Present. Pages 1041-1069 In: Status of the Sierra Nevada, Sierra Nevada Ecosystem Project, Final Report to Congress, vol. II, Assessments and Scientific Basis for Management Options. University of California, Centers for Water and Wildland Resources, Davis.

SNEP (Sierra Nevada Ecosystem Program). 1996. Fire and Fuels, Chapter 4 In: Status of the Sierra Nevada. Final Report to Congress, vol. I, Assessment Summaries and Management Strategies. University of California, Centers for Water and Wildland Resources, Davis.

Ver Steeg, J. M., Harty, F. M. and L. Harty. 1983. Prescribed fire kills meadow voles. In: Restoration and Management Notes. 1(4):21.

Wirtz, W. O. II. 1982. Postfire community structure of birds and rodents in southern California chaparral. In Conrad, C. E., Oechel, W. C., tech. eds. Proceedings of the symposium on dynamics and management of Mediterranean-type ecosystems; 1981 June 22-26; San Diego, CA. Gen. Tech. Rep. PSW-58. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station: 241-246.

Wright, H. A., and A. W. Bailey. 1982. Fire ecology: United States and southern Canada. New York: John Wiley and Sons. 501 pp.

APPENDIX A

CWHR Code Definitions Used In This Report

Habitat Types

Habitat Type	CWHR Code
Annual grassland	AGS
Barren	BAR
Blue oak/foothill pine	BOP
Freshwater emergent wetland	FEW
Mixed chaparral	MCH
Montane hardwood	MHW
Urban/disturbed	URB
Valley foothill riparian	VRI

Tree Size Classes

Diameter breast height	CWHR size class	CWHR code
<1 inch	Seedling tree	1
1-6 inches	Sapling tree	2
6-11 inches	Pole tree	3
11-24 inches	Small tree	4

Tree Cover Classes

Percent canopy closure	CWHR Closure Class	CWHR Code
10-24	Sparse	S
25-39	Open	P
40-59	Moderate	M
60-100	Dense	D

Shrub Size Classes

Crown Decadence	CWHR Size Class	CWHR Code
Seedling< 3 years old	Seedling shrub	1
none	Young shrub	2
1-25 %	Mature shrub	3
>25 %	Decadent shrub	4

Shrub Cover Classes

Percent Ground Cover	CWHR Closure Class	CWHR Code
10-24	Sparse	S
25-39	Open	P
40-59	Moderate	M
60-100	Dense	D

Herbaceous Size Classes

Plant Height At Maturity	CWHR Height Class	CWHR Code
<12 inches	Short herb	1
>12 inches	Tall herb	2

Herbaceous Cover Classes

Percent Ground Cover	CWHR Cover Class	CWHR Code
2-9	Sparse cover	S
10-39	Open cover	P
40-59	Moderate cover	M
60-100	Dense cover	D

APPENDIX B

CWHR Modeling Run Results for High Severity Wildfire Scenario

APPENDIX C

CWHR Modeling Run Results for Shaded Fuelbreak Scenario

APPENDIX D

CWHR Modeling Run Results for Area-wide Fuels Reduction Scenario